interests who made up the road-building organization in Indiana, augurs well for the future of Indiana's roads and the development of a road system which returns full value to the motorist.

While it is but natural to experience a feeling of regret that we are no longer directly concerned with the administration of the state highway system, I take this opportunity to congratulate the motorists of Indiana upon the Commission which has taken up the responsibilities of the state highway system. It is a tribute to the public spiritedness of these men, each experienced in highway affairs and successful in private business, that they give their time and their efforts to the continued development of the highway system.

COOPERATIVE HIGHWAY RESEARCH—A REALITY

R. B. Wiley,
Head, School of Civil Engineering,
Director of Joint Highway Research Project,
Purdue University

The Joint Highway Research Project was established in January, 1936. During the five years since then the idea of performing research on highway materials has developed from paper plans to a modern research organization producing results comparable with those in large industries. In this brief presentation an attempt will be made to give a short historical sketch of the Joint Highway Research Project showing the functions of the Advisory Board, the staff organization, the functions of the Project as representing the State Highway Commission of Indiana and Purdue University, and a brief statement of progress of the researches already undertaken.

At the 1936 Purdue Road School the members of the State Highway Commission of Indiana, Messrs. James D. Adams, John Wheeler, and Evan B. Stotsenburg, discussed the possibilities of performing research on highway materials at Purdue University with various representatives of the University. Many conferences followed, and eventually a skeleton organization was established under a twenty-five thousand dollar allotment of funds from the Commission. These funds were spent entirely under the direction of the Commission. A small Advisory Board was appointed consisting of Messrs. M. R. Keefe, Chief Engineer; A. R. Smith, Engineer of Tests, and M. J. Stinchfield (deceased), Field Engineer of Bituminous Construction representing the Commission, and Professors C. A. Ellis, W. K. Hatt, and B. H. Petty (Chairman) representing the University.

On March 11, 1937, the Project was authorized by an act of the State Legislature[1] in which the Highway Commission was permitted to allocate funds to Purdue University for the operation of the Project. On July 1, 1937, Dr. W. K. Hatt resigned as Head of the School of Civil Engineering and was designated by the University to devote his entire time to the direction of the research activities. He served in this capacity until December 31, 1938, when he retired. Succeeding Dr. Hatt, the writer became Director of the Project and Professor K. B. Woods became Assistant Director acting as a coordinator of all research activities. Under the direction of Dr. Hatt a small full-time staff had been obtained and a plan of study developed. The researches were predominantly on materials used in low-cost roads and on aggregate and bituminous adhesion. This program was expanded during 1939 and 1940 to include a large number of additional studies.

The purposes of the Project are: to make basic studies of materials used in highways in order to facilitate economical design, construction, and maintenance of county and state highways; to investigate traffic, safety, and other miscellaneous items as desired and agreed upon; to provide advanced instruction in the fundamentals of highway engineering and related research; and to provide practical experience in construction and maintenance procedures and use of highway materials.

The Project staff at the present time consists of eight full-time men—K. B. Woods, D. J. Belcher, W. H. Goetz, L. D. Graves, G. W. McAlpin, T. E. Shelburne, C. Slesser, and O. R. Tyler—and eleven graduate assistants—R. F. Baker, H. H. Bonewits, A. K. Branham, R. E. Frost, L. E. Gregg, C. W. Jones, W. J. Kay, T. B. McClelland, H. S. Sweet, F. J. Woodsmall, and E. J. Zegarra.

Because, in part, of the rather unusual organization procedure, the staff is admirably fitted to carry on highway research. The seven full-time men report to the Assistant Director and are in general charge of the research activities in their respective laboratories. The graduate assistants are assigned to the full-time staff, and in turn the undergraduates are assigned to the graduate assistants.

[1] Sec. 26. Joint Road Meetings. The state highway commission may cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof, . . In so co-operating with Purdue University and for the purpose of developing and disseminating helpful information concerning road construction and improvement, and the operation of the highways of the state and the several counties, the state highway commission may expend from the funds appropriated to its use for Miscellaneous Service, not to exceed fifty thousand dollars, annually, for the use and benefit of Purdue University in carrying on programs of highway research and highway extension, at or in connection with Purdue University and for the annual road school held at Purdue University. For the purpose of disseminating knowledge of such highway maintenance methods as are best suited to the various sections of the state, the county and state highway officials, in co-operation with Purdue University, may hold joint road meetings in the various sections of the state. The aid herein authorized shall be paid quarterly, by the state highway commission, to Purdue University, upon proper voucher, commencing on the first day of July, 1937. (As amended Acts 1937, p. 1151.)

It can be seen from the above that the full-time staff is essentially the skeleton organization by means of which the research is accomplished. The graduate assistants are engaged on a half-time basis, the remaining portion of their time being spent in graduate work leading to an advanced degree. Two years are normally required to complete the work for a master's degree and, of course, a longer time is required for the doctorate. Outstanding men have been obtained from colleges and universities all over the country. These men normally adopt a research study as a thesis for their degree. The use of graduate assistants and their training in highway engineering are the outstanding organization developments of the Project. At the same time both academic and practical information are obtained for use by the highway industry in Indiana.

Each researcher attacks his problem by reviewing the results of previous investigations so as to avoid any duplication of effort. This done, a carefully prepared plan of study is developed. These initial preparations consume relatively little time, and a small percentage of the total may prove unprofitable. However, the selection of the numerous lines of research presents a problem of coordination that is necessarily more far-reaching than individual studies.

An Advisory Board reviews all plans and reports prepared by the staff. This Board consists of eight members, four from the State Highway Commission of Indiana—M. R. Keefe (Resigned December 5, 1940); E. B. Lockridge, Chief Engineer; F. F. Havey, Engineer of Materials and Tests; and N. F. Schafer, Engineer of Maintenance, and four from Purdue University—Professors R. B. Crepps, B. H. Petty, P. C. Rutledge, and R. B. Wiley of the staff of the School of Civil Engineering, Purdue University. The Board meets once each month and reviews all manuscripts carefully before their release for technical meetings, publication, and so on. Since the inception of the Project a total of fifty studies has been inaugurated. A great many of these studies have matured and are reported in engineering bulletins of Purdue University, in theses, and in proceedings of various technical organizations, such as the American Society for Testing Materials, Highway Research Board, American Road Builders, Asphalt Paving Technologists, Purdue Road School, and American Concrete Institute. In the past year alone three bulletins have been printed, seven papers delivered before technical organizations, and five theses completed.

Scope of Project

For a detailed presentation of progress you are referred to our new Bulletin No. 71 entitled "Aims and Activities of the Joint Highway Research Project". Investigations are under

way or have been completed on fifty studies to January 30, 1941. Soil stabilization investigations cover eight studies including: Test Road No. 1—two studies on weathering; Test Road No. 2—stabilized surface; Test Road No. 3—base courses; Test Roads Nos. 4, 5, and 6—stabilization; and optimum bitumen content for aggregate-soil mixtures.

Soil studies to be listed are: durability of soil and soil mixtures, frost action in soil and soil mixtures (two studies), laboratory permeability, soil compression, soil mixtures under combined stress, drainage, field soil temperatures, relation of subgrade to pavement performance on state route 17, migration of salts in soil, subgrade stress distribution by photoelastic methods, field permeability, capillarity, and relation of pavement performance to the subgrade on state route No. 62.

Twenty pavement material studies are being undertaken: on surface treatment, aggregate-bitumen mixtures, rock asphalt, bituminous adhesion, degradation of aggregate, chert as a deleterious constituent in aggregate, natural cements, chemistry of bituminous materials, bituminous emulsions, bituminous test procedures, change of structure in asphalt because of weathering, and traffic paints.

Five miscellaneous studies are listed—psychological aspects of highway safety (covering bibliography, development of equipment, and field observations), use of mass diagram in highway engineering, application of photography to highway research, and aerial photography.

From May 2, 1939, to December 31, 1939, fourteen progress reports were submitted to the Advisory Board totalling 784 pages, 372 figures, and 99 tables. From January 1, 1940, to December 31, 1940, thirty-three progress reports were submitted, totalling 1,140 pages, 328 figures, and 153 tables. A detailed listing of the project bulletins, papers, and theses is appended.

The program of research as now developed includes work on soils, stabilization, bituminous materials and mixes, and portland cement concrete and traffic and materials studies. In some cases these studies are applicable for use only by the State Highway Commission of Indiana, but, in general, the studies are of importance and may be used by the counties and states of the nation. Purdue is proud of the part it is playing in developing more fundamental information on the performance and use of highway materials.

In the papers to follow in this program you will find ample opportunity to obtain some practical information resulting from several of the current researches of the Joint Highway Research Project. No attempt has been made to give you the results of all of the researches under way. Rather, an endeavor has been made to present a summary of some of the more practical studies and those that are particularly applicable to the counties in Indiana.

To illustrate, Mr. Shelburne in his discussion of surface treatment problems will try to show you why certain treatments perform satisfactorily and why others do not. Since there is a large mileage of surface treatments in the state highway system and in the counties, the points stressed in his presentation should be of considerable interest to most of you.

Likewise, the studies on drainage that are to be presented by Mr. G. W. McAlpin should be of general interest to most of you. You will no doubt be interested in the slides showing the flow patterns of water as it goes through soil to a drain. This is new information and will help you visualize the usefulness and effectiveness of highway drains.

A third subject of particular interest to counties, as well as the state highway engineers, is the matter of stabilization. Most of you know that there has been a great amount of research in the field of soil stabilization. Mr. Belcher, in his presentation, will summarize some of the more practical findings resulting from a half-dozen or more extensive research studies in this field.

Other papers on the program include one on traffic paints by W. H. Goetz, one on the physical characteristics of rock asphalt by O. R. Tyler, and one on the migration of calcium and sodium chlorides in soil by Charles Slesser. Although these papers are not all of direct interest to each of you, you may be able to obtain some new ideas and some worthwhile information from them.

BULLETINS, PAPERS, AND THESES BY YEARS

JOINT HIGHWAY RESEARCH PROJECT

January 1, 1936, to January 30, 1941

1938

1. "Adhesion of Bitiuminous Films to Aggregates", by O. R. Tyler, Research Chemist. *Engineering Bulletin of Purdue University,* Research Series No. 62, September, 1938, 35 pp.
2. "Frost Action in Stabilized Soil Mixtures", by H. F. Winn, Research Assistant. *Proceedings of the Eighteenth Annual Meeting of the Highway Research Board,* Vol. 18, Part 1, pp. 264-290, 1938 *(Engineering Reprint of Purdue University, No. 1).*
3. "The Cooperative Highway Research Project", by W. K. Hatt, former Director, Joint Highway Research Project. *Ibid.,* pp. 255-263, 1938.

1939

4. "The Cooperative Highway Research Project", by W. K. Hatt, former Director, Joint Highway Research Project, Purdue University. *Engineering Bulletin of Purdue University,* Extension Series No. 44, January, 1939.

5. "Highway Embankment Construction Procedure", by K. B. Woods. *Ibid.*
6. "Relation of Soil Studies to Highway Engineering", by K. B. Woods. Presented at the February, 1939, convention of the Ohio Society of Professional Engineers, Cincinnati, Ohio.
7. "A Review of the Literature Related to the Various Psychological Aspects of Highway Safety", by C. H. Lawshe, Jr., Research Assistant. *Engineering Bulletin of Purdue University*, Research Series No. 66, April, 1939.
8. "Degradation of Aggregates Under Road Rollers", by T. E. Shelburne, Research Engineer. *Proceedings of the Forty-second Annual Meeting of the American Society for Testing Materials*, Vol. 39, pp. 950-970, 1939. *(Engineering Reprint of Purdue University, No. 2.)*
9. "Frost Action in Stabilized Soil Mixtures", by H. F. Winn. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering, June, 1939.
10. "Stabilized Soil Compression Studies", by R. I. Mayo. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering, June, 1939.
11. "Degradation of Aggregates Under Road Rollers", by T. E. Shelburne. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering, August, 1939.

1940

12. "Aims and Activities of the Joint Highway Research Project", by K. B. Woods. *Engineering Bulletin of Purdue University*, Research Series No. 71, March, 1940.
13. "Frost Action in Highway Bases and Subgrades", by H. F. Winn and P. C. Rutledge. *Engineering Bulletin of Purdue University*, Research Series No. 73, May, 1940.
14. "Crushing Resistance of Surface-Treatment Aggregates", by Tilton E. Shelburne. *Engineering Bulletin of Purdue University*, Research Series No. 76, September, 1940.
15. "Highway Research on Soils, Paving Materials, and Traffic", by the Staff, Joint Highway Research Project. *Engineering Reprint of Purdue University*, No. 3.
16. "A Field Investigation of Stabilized Materials Used as Highway Base Courses". A thesis submitted to the faculty of Purdue University by Donald Jenks Belcher in partial fulfillment of the requirements for the degree of Master of Science in Engineering, June, 1940.
17. "Investigational Tests on Chert". A thesis submitted to the faculty of Purdue University by Frederick W. Fisher in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering, June, 1940.
18. "Field Studies of Migration of Calcium Chloride and Sodium Chloride in Soil". A thesis submitted to the faculty of Purdue University by Charles Slesser in partial fulfillment of the requirements for the degree of Master of Science in Engineering, June, 1940.
19. "A Laboratory Study of Bituminous Road Mixtures". A thesis submitted to the faculty of Purdue University by Leroy Donald Graves

in partial fulfillment of the requirements for the degree of Master of Science in Engineering, August, 1940.

20. "Capillarity of Soils". A thesis submitted to the faculty of Purdue University by Hsien-Hsiang Ku in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering, June, 1940.
21. "Soil Stabilization Research at Purdue University", by K. B. Woods. *Convention Proceedings, American Road Builders' Association,* 1940, pp. 336-350.
22. "Surface Treatment Studies", Tilton E. Shelburne. *Proceedings of the Association of Asphalt Paving Technologists.* Vol. II, January, 1940, pp. 44-59.
23. "Design and Construction of Highway Embankments", by K. B. Woods. *Proceedings of the Purdue Conference on Soil Mechanics and Its Application,* July, 1940, pp. 355-366.
24. "Subgrade Soil Temperatures", by D. J. Belcher. *Ibid.,* pp. 474-482.
25. "Current Practices in Stabilization", by D. J. Belcher, G. W. McAlpin, and K. B. Woods. *Ibid.,* pp. 419-444.
26. "Highway Research in Indiana", by K. B. Woods. Presented at the fall meeting of the American Society of Civil Engineers, Cincinnati, Ohio, October, 1940.
27. "Chert as a Deleterious Constituent in Indiana Aggregates", by H. S. Sweet. Presented at the annual meeting of the Highway Research Board, December, 1940.

1941 (to January 30)

29. "Natural Sandstone Rock Asphalt", by O. R. Tyler, W. H. Goetz, and C. Slesser. *Engineering Bulletin of Purdue University,* Research Series No. 78, January, 1941.
30. "Structure Study of Bituminous Materials". A thesis submitted to the faculty of Purdue University by Harold H. Bonewits in partial fulfillment of the requirements for the degree of Master of Science in Engineering, January, 1941.
31. "Properties of Portland and Blended Cement Concretes with Regard to Water Loss, Water Regain, and Other Physical Characteristics". A thesis submitted to the faculty of Purdue University by Chester W. Jones in partial fulfillment of the requirements for the degree of Master of Science in Engineering, January, 1941.
32. "A Study of Chert as a Deleterious Constituent in Highway Aggregates". A thesis submitted to the faculty of Purdue University by Harold S. Sweet in partial fulfillment of the requirements for the degree of Master of Science in Engineering, January, 1941.
33. "Field Studies in Stabilization", by D. J. Belcher. Presented at the Twenty-seventh Annual Purdue Road School, January, 1941.
34. "Fundamentals in Surface Treatment Construction", by T. E. Shelburne. *Ibid.*
35. "Physical Characteristics of Rock Asphalt", by O. R. Tyler. *Ibid.*
36. "Model Studies on Roadway Drainage", by G. W. McAlpin. *Ibid.*
37. "Traffic Paint Studies", by W. H. Goetz. *Ibid.*

38. "Migration of Calcium and Sodium Chlorides in Soil", by Charles Slesser. *Ibid.*
39. "Cooperative Highway Research—A Reality", by R. B. Wiley. *Ibid.*
40. "Application of Photography to Highway Research", by R. E. Frost. *Ibid.*
41. "Engineering and Construction Control of Embankments and Bases", by K. B. Woods. Presented at the Annual Convention of the American Road Builders' Association, New York City, January 28, 1941.

Summary of Joint Highway Research Project Studies

Project	Assign.	Month and Year	Title of Project	Key No.	Type of Study
C-36-1			**Test Road No. 1**		
C-36-2	R. F. Jackson*	1937	Part A—Old Series	1	Stabilization
	D. J. Belcher	Oct. 1939	Part B—New Series	1	Stabilization
C-36-3	R. F. Jackson*	1938	**Test Road No. 2—Base**	5	Stabilization
C-36-4	T. E. Shelburne	1936	**Surface Treatment**		
			Part A—1935, older	5	Pavement Materials
			Part B—1936 Series	5	Pavement Materials
			Part C—1937 Series	5	Pavement Materials
C-36-5			**Soil Stabilization**		
	L. D. Graves	1938	Part A—Durability	1	Soil
	H. F. Winn*	1938	Part B—Frost Action	2	Soil
	W. J. Kay	Dec. 1939	Part C—Permeability	6	Soil
	R. I. Mayo*	1938	Part D—Compression	1	Soil
	C. Slesser	1940	Part E—Frost Action—New Series	6	Soil
C-36-6			**Bituminous Mixtures**		
	L. D. Graves	Oct. 1939	Part A—Pugmill	5	Pavement Materials
		Feb. 1939	Part B—Patch	5	Pavement Materials
C-36-7	O. R. Tyler	1938	**Rock Asphalt**	5	Pavement Materials
C-36-8			**Bituminous Adhesion**		
	O. R. Tyler	1937	Part A—Untreated	2	Pavement Materials
	None	May 1940	Part B—Admixtures	3	Pavement Materials
C-36-9			**Aggregate Degradation**		
	T. E. Shelburne	1938	Part A—Uncoated	2	Pavement Materials
		1939	Part B—Coated	2	Pavement Materials
C-36-10			**Traffic Research**		
	C. H. Lawshe*	1938	Part A—Bibliography	2	Miscellaneous
	A. K. Branham	1939-1940	Part B—Field	6	Miscellaneous
C-36-11	D. J. Belcher	1939	**Equipment**	1	Miscellaneous
C-36-12	T. E. Shelburne	May 1939	**Test Road No. 3**	6	Pavement Materials
C-36-13	D. J. Belcher	Oct. 1939	**Test Road No. 2—Surface Treatment**	5	Stabilization
C-36-14	L. E. Gregg	Dec. 1939	**Tri-axial Compression**	6	Soil
C-36-15	G. W. McAlpin	Dec. 1939	**Drainage**	6	Soil
C-36-16	D. J. Belcher	Oct. 1939	**Field Soil Temperatures**	6	Soil

Project	Assign.	Month and Year	Title of Project	Key No.	Type of Study
C-36-17	T. E. Shelburne	May 1939	**Performance—S. R. 17**	1	Soil
C-36-18	H. S. Sweet	Aug. 1939	**Chert**	6	Pavement Materials
C-36-19			**Natural Cement**		
	C. W. Jones	Aug.	Part A—Physical Tests	6	Pavement Materials
	J. M. Robertson*	1939	Part B—Cores	6	Pavement Materials
			Part C—Fatigue	1	Pavement Materials
C-36-20	C. Slesser	Aug. 1939	**Salt Migration**	6	Soil
C-36-21	O. R. Tyler	1939	**Chemistry of Bitumens**	3	Pavement Materials
C-36-22	O. R. Tyler	June 1940	**Bituminous Emulsions**	6	Pavement Materials
C-36-23	None	1939	**Bit. Test Procedures**	3	Pavement Materials
C-36-24	H. H. Bonewits	May 1940	**Asphalt Structures**	6	Pavement Materials
C-36-25	R. E. Frost	May 1940	**Photography**	6	Miscellaneous
C-36-26	W. H. Goetz	Apr. 1940	**Traffic Paints**	6	Pavement Materials
C-36-27	T. E. Shelburne	June 1940	**Test Road No. 4**	6	Stabilization
C-36-28	F. J. Woodsmall	June 1940	**Photoelasticity**	6	Soil
C-36-29	J. M. Robertson*	June 1940	**Field Permeability**	3	Soil
C-36-30	L. D. Graves	Sept. 1940	**Optimum Bitumen for Soil**	6	Stabilization
C-36-31	None	1940	**Performance—S. R. 62**	3	Soil
C-36-30	L. D. Graves	Sept. 1940	**Aerial Photography**	6	Miscellaneous
C-36-33	G. W. McAlpin	July 1940	**Test Road No. 5**	6	Stabilization
C-36-34	D. J. Belcher	1940	**Test Road No. 6**	6	Stabilization
C-36-35	T. E. Shelburne	Jan. 1941	**Concrete Performance Survey**	4	Pavement Materials
C-36-36	T. B. McClelland	Sept. 1940	**Capillarity**	4	Soil
C-36-37	D. J. Belcher	Jan. 1941	**Sonic Measurements**	4	Pavement Materials
C-36-38	D. J. Belcher	Jan. 1941	**Soil Mapping**	4	Soil

KEY TO STATUS NUMBERS

Key Number		Total No. of Studies
1	Complete—Unpublished	7
2	Complete—Pupblished	7
3	Incomplete—Inactive	5
4	Being Inaugurated	4
5	Complete—Publication in Progress	8
6	Active—Incomplete	21
	Grand Total	50

* Resigned.